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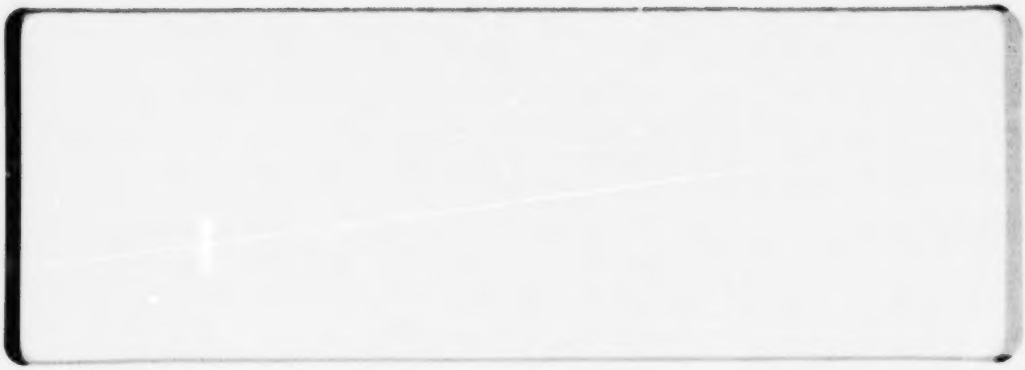

ESTIMATES OF RESEARCH AND DEVELOPMENT PERSONNEL,

1975-1984

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INTRODUCTION

Today, Canada's economic growth, like that of every other industrialized country, is tied to the development of its scientific and technological base. Of all the factors needed for a country's scientific and industrial development, the supply of suitable human resources is unquestionably one of the most vital. Thus, the formulation of science and technology policy requires reliable information on these human resources, especially those engaged in research and development (R&D). "... unless people with certain training and qualifications are available, organized R&D is almost impossible. Education and training are lengthy processes; personnel data are, therefore, essential to realistic science policy planning".(1)

The numbers of R&D personnel are also considered a supplementary measure to intramural expenditures on R&D. The Frascati Manual states that "personnel is a more concrete measure and, since labour costs normally account for 50-70 per cent of total R&D expenditures, is also a reasonable short-term indicator of efforts devoted to R&D".(2)

It is therefore important to determine the status of these resources on a regular basis. In this report, we shall present some statistical estimates and definitions concerning R&D personnel. Data on R&D personnel are derived from surveys conducted by the Science, Technology and Capital Stock Division and from estimates based on various data sources. For convenience of presentation, the data are grouped into three occupational categories:

- scientists and engineers
- technicians
- other support staff

and classified into five sectors of the employing institutions:

- federal government
- provincial government (includes provincial research organizations)
- business enterprise
- higher education
- private non-profit.

Wherever possible, the data are also classified by major field of science; natural sciences and engineering (NSE) or social sciences and humanities (SSH).

Appendix II contains a technical note briefly describing the classification systems used as well as definitions and abbreviations of select terms. For more detail on the methods used to estimate R&D personnel, see **Human Resources in Science and Technology,** Statistics Canada, Catalogue No. 88-508E (forthcoming).

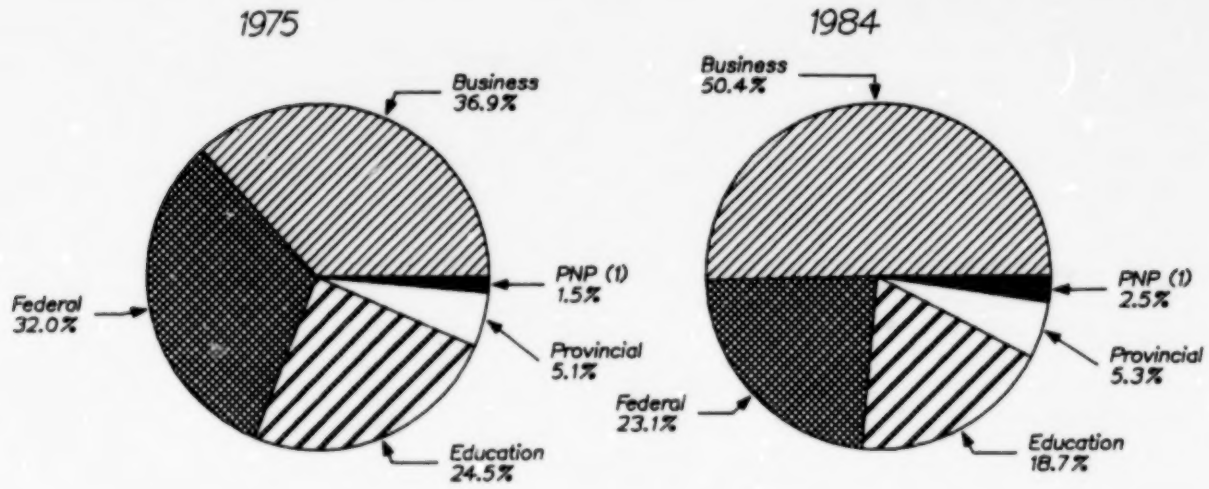
1. All Sectors

Between 1975 and 1984, total R&D personnel (3) increased from 53,800 to 76,670 up 43%. Excluding the federal government and higher education sectors, where growth has been sluggish, all other sectors posted increases in excess of 40% (see Appendix Table 1).

Chart 1 shows that in 1984, 50.4% of R&D personnel were employed in business enterprises, compared with 23.1% in the federal government, 18.7% in higher education establishments, 5.3% in the provincial government sector and 2.5% in private non-profit organizations. Moreover, the share of R&D personnel employed by business enterprises increased substantially between 1975 and 1984, while the proportions employed by the federal government and higher education sectors declined.

According to the data in Table 1, in 1984 almost half of the persons engaged in R&D were scientists and engineers, 28% were technicians and 24% were other support staff. The first group also had the highest growth rate over the 1975-84 period, 57% compared with 42% for the technicians category and 20% for other support staff. In addition, over 85% of all scientists, engineers and other support staff were concentrated in the NSE field, which means this field was responsible for almost all of the growth in these two categories. (The technicians category refers to the NSE field only: the few technicians engaged in R&D in the SSH have been included with the other support staff category.)

Chart 1 – Distribution of R&D Personnel by Sector, 1975 and 1984



(1) Private non-profit.

Source: Appendix Table 1.

TABLE 1. Personnel Engaged in R&D, All Sectors, by Occupation

Year	Scientists and engineers			Technicians	Support staff			Total
	NSE	SSH	Total	NSE	NSE	SSH(1)	Total	
	person-years (rounded to the nearest 10)							
1975 ...	18,800	4,840	23,640	14,870	12,340	2,950	15,290	53,800
1976 ...	19,930	4,870	24,800	14,980	12,200	2,920	15,120	54,900
1977 ...	20,860	4,720	25,580	15,280	12,040	2,810	14,850	55,710
1978 ...	21,980	4,650	26,630	15,520	12,710	2,820	15,530	57,680
1979 ...	22,810	4,580	27,390	15,850	13,230	2,760	15,990	59,230
1980 ...	24,750	4,570	29,320	17,460	13,650	2,750	16,400	63,190
1981 ...	26,700	4,580	31,280	19,110	14,280	2,770	17,050	67,440
1982 ...	29,430	4,600	34,030	19,890	14,670	2,780	17,450	71,370
1983 ...	30,240	4,630	34,870	19,680	15,980	2,820	18,800	73,350
1984 ...	32,520	4,620	37,140	21,130	15,640	2,760	18,400	76,670

Source: Appendix Tables 2, 3 and 4.

(1) Includes the few technicians engaged in R&D in the social sciences and humanities.

NSE = Natural sciences and engineering.
SSH = Social sciences and humanities.

2. Federal Government

This sector comprises all federal departments and ministries of state, and most federal agencies; all employees are included (indefinite, temporary and casual status). The data on persons engaged in R&D in the federal government are taken both from the annual survey of the scientific and technological activities of federal institutions and from information provided in the **Main Estimates**, tabled annually in Parliament by the President of the Treasury Board.(4) These data are classified into three occupational categories: scientists and engineers, technicians and other support staff. The allocation of personnel to these classes is based on their public service classifications (e.g., all persons in the "scientific and professional" category would be considered "scientists and engineers"). Due to the nature of the work in the social sciences and humanities it is sometimes difficult to distinguish between technicians and other support staff; for convenience, these two categories have been combined.

Table 2 shows that the sluggish growth of R&D personnel in the federal government between 1975 and 1984 was due to a decrease in SSH person-years (-58%), offsetting a slight expansion in the NSE (7%). Because the proportion of federal R&D personnel employed in the SSH field is so small (4%), this decline had little impact on the total. It did, however, affect both the scientists and engineers and support staff categories. In the NSE, there was a notable increase in the number of scientists and engineers and a small decrease in the number of technicians, probably attributable to the staffing practices of agencies with very restricted R&D budgets.

On the basis of Appendix Table 5, the departmental distribution of R&D personnel in the NSE has remained virtually unchanged. In 1975 and in 1984 Agriculture Canada, Atomic Energy of Canada Limited and the National Research Council accounted for over 55% of all R&D personnel in the NSE. In addition, in 1984 Agriculture Canada employed the greatest number of scientists and engineers, technicians and other support staff. In 1983, responsibility for the Canadian Forestry Service Program was transferred from Environment Canada to Agriculture Canada.

Table 4 shows the distribution of SSH scientists and support staff in federal government departments. Statistics Canada and the Economic Council of Canada were the major employers of SSH personnel (41%).

TABLE 2. Personnel Engaged in R&D in the Federal Government, by Occupation

Year(1)	Scientists and engineers			Technicians	Support staff			Total
	NSE	SSH	Total	NSE	NSE	SSH(1)	Total	
	person-years (rounded to the nearest 10)							
1975 ...	5,430	980	6,410	5,150	5,080	550	5,630	17,190
1976 ...	5,620	930	6,550	4,910	4,980	480	5,460	16,920
1977 ...	5,650	700	6,350	4,860	4,870	390	5,260	16,470
1978 ...	5,870	630	6,500	4,760	4,930	390	5,320	16,580
1979 ...	5,790	560	6,350	4,680	4,850	370	5,220	16,250
1980 ...	5,800	480	6,280	4,680	4,790	340	5,130	16,090
1981 ...	5,890	510	6,400	4,870	4,990	330	5,320	16,590
1982 ...	6,310	480	6,790	4,830	5,270	280	5,550	17,170
1983 ...	6,400	410	6,810	4,680	5,500	230	5,730	17,220
1984 ...	6,510	420	6,930	4,860	5,390	230	5,620	17,410

Source: Appendix Tables 2, 3 and 4.

(1) 1975 = fiscal year 1 April 1975 - 31 March 1976, and so on.
(2) Includes the few technicians engaged in R&D in the social sciences and humanities.

NSE = Natural sciences and engineering.
SSH = Social sciences and humanities.

TABLE 3. Federal Employees Engaged in R&D in the Natural Sciences and Engineering, by Occupation and Department, 1984-85

Department	Scientists and engineers	Technicians	Support staff	Total
	person-years			
Agriculture Canada ...	1,349	1,306	2,072	4,727
Atomic Energy of Canada Ltd.	739	910	835	2,484
Energy, Mines and Resources	913	397	345	1,655
Environment Canada ...	491	135	242	867
Fisheries and Oceans	621	482	430	1,533
National Defence	665	471	648	1,782
National Research Council	1,260	936	645	2,841
Other	469	227	173	870
Total	**6,507**	**4,863**	**5,390**	**16,759**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

TABLE 4. Federal Employees Engaged in R&D in the Social Sciences and Humanities, by Occupation and Department, 1984-85

Department	Scientists	Support staff	Total
	person-years		
Canada Mortgage and Housing Corporation	21	13	34
Canadian Transport Commission	21	13	34
Consumer and Corporate Affairs	6	9	35
Economic Council of Canada ...	68	45	113
Law Reform Commission	2	5	7
National Museums of Canada ...	60	-	60
Secretary of State	45	5	50
Statistics Canada	95	59	154
Other	85	82	167
Total	**423**	**231**	**653**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

3. Provincial Governments

The provincial government sector consists of all provincial government departments, ministries and agencies and provincial research organizations.

Government Departments and Agencies

Each year, the Science, Technology and Capital Stock Division assists the governments of seven provinces (British Columbia, Alberta, Saskatchevan, Manitoba, Ontario, New Brunswick and Newfoundland) to carry out surveys of resources devoted to their scientific and technological activities. Since 1983, Quebec has conducted its own survey of provincial government science activities. Provincial R&D person-years and their occupational distribution are estimated on the basis of the annual expenditure/person ratios for three of the surveyed provinces and the annual estimates of total R&D expenditures for all provinces.(5)

Provincial Research Organizations

Statistics on the R&D personnel of provincial research organizations are estimated on the basis of an annual survey of the resources of the eight provincial foundations and councils.

R&D is only one of the activities of these provincial research organizations. In the survey conducted by the Science, Technology and Capital Stock Division, they are asked to allocate their expenditures by a number of activities, including R&D. The total number of personnel for all organizations is multiplied by the ratio of R&D to total expenditures to produce an estimate of R&D personnel. Since the three occupational categories are already specified in the survey, (6) their relative proportions are applied to the R&D person-year total.

Between 1975 and 1984, the number of provincial employees engaged in R&D increased by 45%: the individual growth rate for the provincial research organizations was 54% and for the government departments, 43%. The government departments accounted for 70% of all NSE personnel in this sector for 1984. (See Appendix tables 2-4.)

TABLE 5. Personnel Engaged in R&D in the Provincial Government Sector, by Occupation

Year(1)	Scientists and engineers			Technicians	Support staff			Total
	NSE	SSH	Total	NSE	NSE	SSH(2)	Total	
	person-years (rounded to the nearest 10)							
1975 ...	930	330	1,260	780	510	180	690	2,730
1976 ...	1,040	340	1,380	860	570	190	760	3,000
1977 ...	1,150	350	1,500	880	630	160	790	3,170
1978 ...	1,150	300	1,450	900	690	170	860	3,210
1979 ...	1,210	320	1,530	1,000	740	180	920	3,450
1980 ...	1,210	370	1,580	1,130	760	200	960	3,670
1981 ...	1,230	340	1,570	1,100	730	260	990	3,660
1982 ...	1,510	360	1,870	1,280	800	300	1,100	4,250
1983 ...	1,340	420	1,760	1,140	870	370	1,240	4,140
1984 ...	1,330	380	1,710	1,110	860	290	1,150	3,970

Source: Appendix Tables 2, 3 and 4.

(1) 1975 = fiscal year 1 April 1975 - 31 March 1976, and so on.
(2) Includes the few technicians engaged in R&D in the social sciences and humanities.

NSE = Natural sciences and engineering.
SSH = Social sciences and humanities.

4. Business Enterprises

For the purposes of the Science, Technology and Capital Stock Division, the term "business enterprises" encompasses all private and public enterprises, and industrial research institutes.

Between 1970 and 1981, complete personnel data for firms performing R&D were collected only in odd-numbered years (major R&D performers were sampled in even-numbered years). Estimates for 1976, 1978 and 1980 were computed by averaging the figures for 1975 and 1977, 1977 and 1979, and 1979 and 1981, respectively. Since 1982, however, all performers, regardless of size, have been surveyed annually. Note that the data are for the natural sciences and engineering only. For further information, see **Industrial Research and Development Statistics,** Statistics Canada, Catalogue No. 88-202.

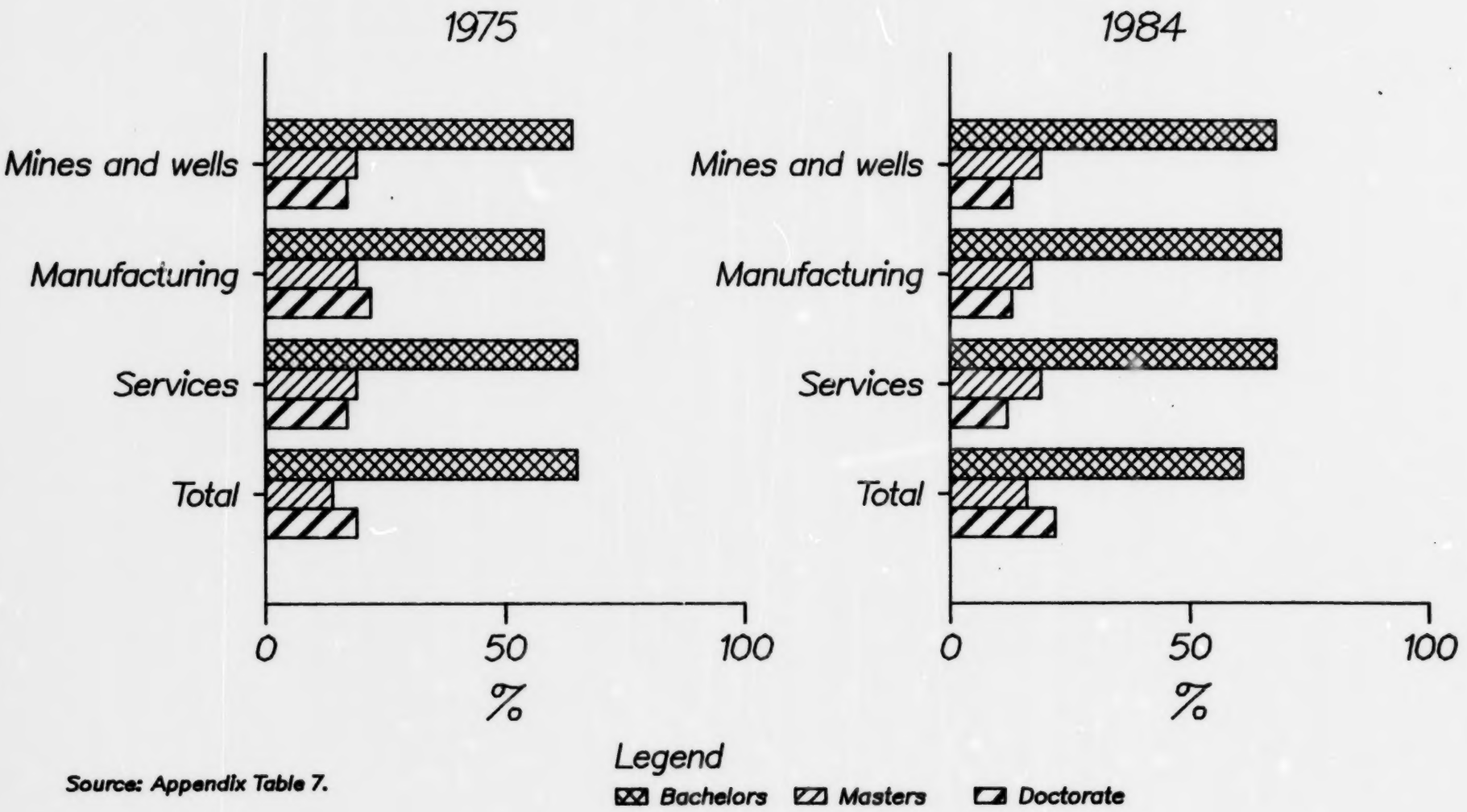
As in the case of the other sectors, the personnel data can be broken down by occupational category. Table 6 shows that total R&D personnel in the business sector almost doubled over the nine-year period. There were notable differences in growth among the three occupational categories: scientists and engineers, 134%; technicians, 92%; and other support staff, 46%. In 1984, the first category accounted for 50% of total R&D personnel, compared with 32% for technicians and 18% for other support staff.

The survey also provides a breakdown of personnel by industry, except those industries in which little or no R&D is performed - trade, finance, business insurance and real estate, community and personal services and most service businesses. Appendix Table 6 shows that almost 75% of R&D personnel work in manufacturing. Of this total, 21% are employed in the telecommunication equipment industry, 12% in the aircraft industry and 7% in the business machines industry. These industries employ the largest numbers of scientists and engineers in manufacturing (note also 'other chemical products'). In the services sector, engineering and scientific services employ 31% of all scientists and engineers; transportation and other utilities employ 27%.

A breakdown by degree level, illustrated in Chart 2, shows that, in 1984 almost 70% of R&D personnel in the professional category (i.e., scientists and engineers) had bachelors degrees, while 19% had masters degrees and 13% doctorates. It is worth noting that in 1984 the mining and oil wells sector employed the largest relative percentage of Ph.Ds (23%). In 1975 both the services and manufacturing sectors had larger representations of doctorate holders (23% and 17%, respectively) than they did in 1984 (14% and 13%).

A more detailed examination shows that doctorate holders were concentrated in the telecommunication equipment, chemicals, drugs and medicines and electric power industries (see Appendix Table 8).

Chart 2 — Distribution of Professional Personnel Engaged in R&D, by Industry Group and Degree Level, 1975 and 1984



Source: Appendix Table 7.

TABLE 6. Personnel Engaged in R&D in the Business Enterprise Sector, by Occupation

Year	Scientists and engineers	Technicians	Support staff	Total
	person-years (rounded to the nearest 10)			
1975	8,320	6,590	4,960	19,870
1976	9,020	6,910	4,800	20,730
1977	9,720	7,230	4,640	21,590
1978	10,520	7,570	5,150	23,240
1979	11,310	7,910	5,650	24,870
1980	13,090	9,450	6,080	28,630
1981	14,870	11,000	6,510	32,380
1982	16,790	11,550	6,510	34,850
1983	17,590	11,480	7,470	36,540
1984	19,480	12,630	7,230	39,340

Source: Appendix Tables 2, 3 and 4.

5. Higher Education Establishments

This sector includes universities, colleges of technology and other institutions of postsecondary education. Since existing surveys of this sector do not provide information on the R&D activities of staff it is necessary to estimate R&D personnel.

The full-time equivalent of persons in this sector engaged in R&D was calculated from census occupation data and the results of a survey of full-time teachers conducted by the Education, Culture and Tourism Division. Personnel are allocated to the NSE and SSH fields and occupational categories using ratios; the final step produces full-time equivalent data by means of coefficients. A detailed explanation of the procedure for estimating R&D personnel in the higher education sector is given in **Human Resources in Science and Technology,** Statistics Canada, Catalogue No. 88-508E (forthcoming).

The results of this estimation process are presented in Table 7. Since the distinction between technicians and other support staff is unclear in the SSH, these two categories have been combined for publication.

The use of large-scale estimates naturally causes data reliability problems. Nevertheless, in the absence of more reliable data, these estimates provide us with a general idea of the situation in this sector, given certain assumptions. Because of the lack of information on part-time university staff, and the role of students as support staff, the personnel estimates for this sector are understated in comparison with other sectors. Caution should be used when comparing them with other sectors or with expenditure estimates.

As a final note, the estimation procedure for the higher education's personnel statistics is currently under investigation. A note addressing proposed changes should be available in the Fall for comment.

TABLE 7. Personnel Engaged in R&D in the Higher Education Sector, by Occupation

Year	Scientists and engineers			Technicians	Support staff			Total
	NSE	SSH	Total	NSE	NSE	SSH(1)	Total	
	person-years (rounded to the nearest 10)							
1975 ...	3,880	3,530	7,410	1,980	1,590	2,220	3,810	13,200
1976 ...	4,000	3,600	7,600	1,920	1,640	2,250	3,890	13,410
1977 ...	4,050	3,670	7,720	1,880	1,660	2,260	3,920	13,520
1978 ...	4,100	3,720	7,820	1,790	1,660	2,260	3,920	13,530
1979 ...	4,160	3,700	7,860	1,750	1,710	2,210	3,920	13,530
1980 ...	4,290	3,720	8,010	1,670	1,720	2,210	3,930	13,610
1981 ...	4,310	3,730	8,040	1,550	1,720	2,180	3,900	13,490
1982 ...	4,390	3,760	8,150	1,580	1,730	2,200	3,930	13,660
1983 ...	4,400	3,800	8,200	1,590	1,750	2,220	3,970	13,760
1984 ...	4,580	3,820	8,400	1,650	1,810	2,240	4,050	14,100

Source: Appendix Tables 2, 3 and 4.

(1) Includes the few technicians engaged in R&D in the social sciences and humanities.

NSE = Natural sciences and engineering.
SSH = Social sciences and humanities.

6. Private Non-profit Organizations

This sector is comprised of private and semipublic organizations and entities for which profit-making is not a primary goal.(7) There are four main types of organizations included: philanthropic foundations, scientific societies and associations, voluntary health organizations, and research institutes which do not belong to other sectors.

Since 1983, the Science, Technology and Capital Stock Division has been collecting personnel data through its survey of R&D performed by private non-profit organizations in Canada. In this survey, respondents are asked to estimate the number of employees engaged in R&D by occupational category.(8)

Since no statistics on R&D personnel in these organizations for the years prior to 1983 are available, estimates were made based on the 1983 relationships of personnel, R&D expenditures and occupational categories. Finally, since R&D in this sector is carried out basically in the health sciences, there are no estimates for personnel engaged in R&D in the social sciences and humanities. A detailed explanation of the procedure for estimating R&D personnel in the private non-profit sector is given in **Human Resources in Science and Technology**, Statistics Canada, Catalogue No. 88-508E (forthcoming).

TABLE 8. Personnel Engaged in R&D in the Private Non-profit Sector, by Occupation

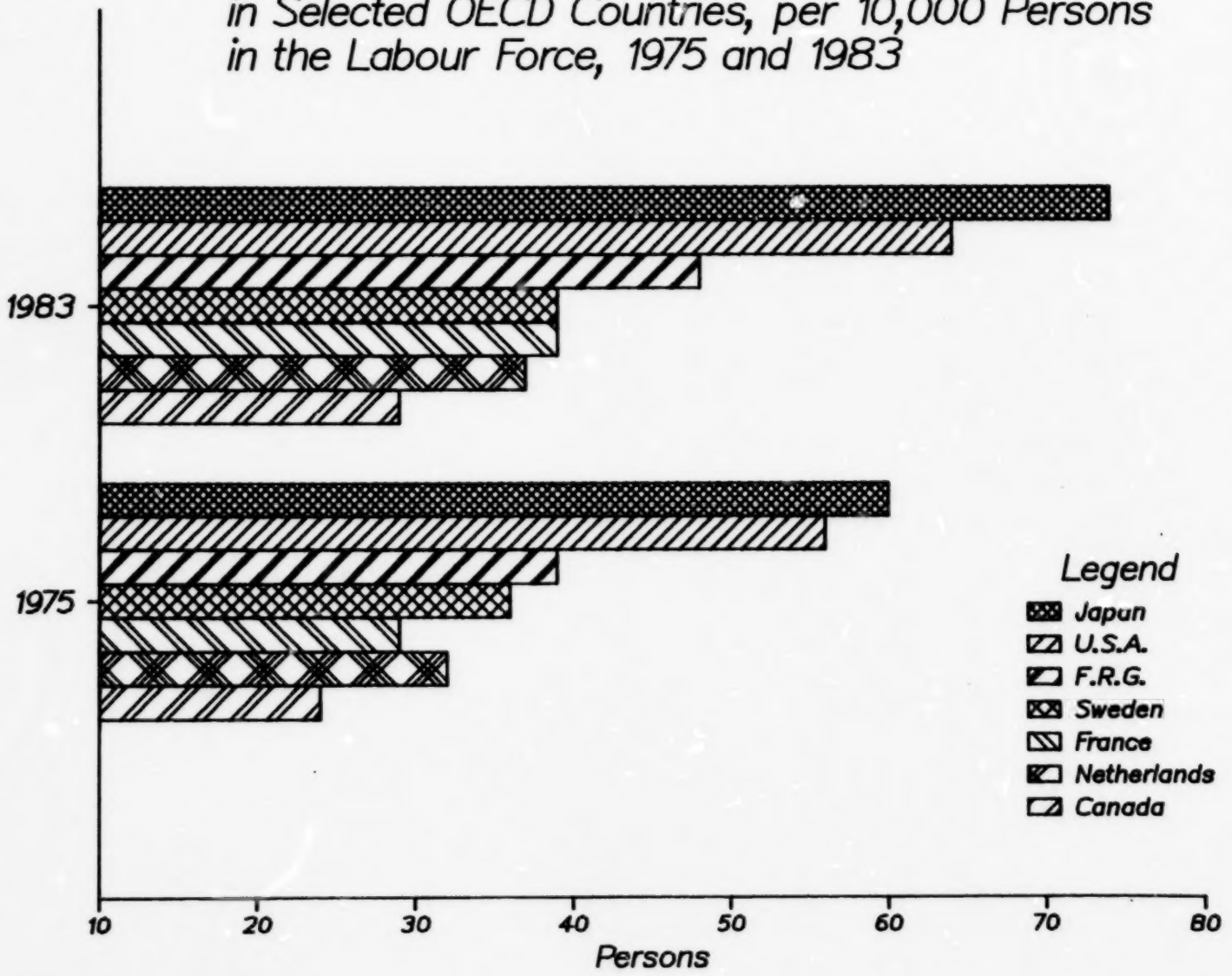
Year	Scientists and engineers	Technicians	Support staff	Total
	person-years (rounded to the nearest 10)			
1975 ...	240	370	200	810
1976 ...	250	380	210	840
1977 ...	290	430	240	960
1978 ...	340	500	280	1,120
1979 ...	340	510	280	1,130
1980 ...	360	530	300	1,190
1981 ...	400	590	330	1,320
1982 ...	430	650	360	1,440
1983 ...	510	790	390	1,690
1984 ...	620	880	350	1,850

Source: Appendix Tables 2, 3 and 4.

7. International Comparisons

In 1983 in Canada, there were three 'scientists and engineers' engaged in R&D for every 1,000 members of the labour force, compared with seven in Japan, six in the United States, five in the Federal Republic of Germany and four in France, Sweden and the Netherlands. Since 1975 the proportion of scientists and engineers in the labour force has increased substantially in four of these countries excepting Canada, the Netherlands and Sweden, where it remained relatively stationary.

Chart 3 – Scientists and Engineers Engaged in R&D in Selected OECD Countries, per 10,000 Persons in the Labour Force, 1975 and 1983



Source: Appendix Table 9.

FOOTNOTES

1 **The Measurement of Scientific and Technical Activities, "Frascati Manual", 1980,** OECD, Paris, 1981, p. 19. This publication is an international guide for the collection of R&D statistics.

2 **Ibid**, p. 19.

3 All R&D personnel data are expressed in terms of person-years. To make the text more readable, we have used person-years, personnel and persons synonymously in comments concerning the data. This does not, however, imply that the number of person-years and the number of persons are equivalent measures.

4 For further details, see **A Framework for Measuring Research and Development Expenditures in Canada,** Statistics Canada, Catalogue No. 88-506E, 1984.

5 For further details, see **Human Resources in Science and Technology,** Statistics Canada, Catalogue No. 88-508E (forthcoming).

6 For further information, see "The Provincial Research Organizations, 1985", **Science Statistics,** Vol. 10, No. 9, Statistics Canada, Catalogue No. 88-001, October 1986.

7 For further information about definitional criteria, see **A Framework for Measuring Research and Development Expenditures in Canada,** Statistics Canada, Catalogue No. 88-506E, 1984.

8 See "R&D Expenditures of Private Non-profit Organizations, 1985", **Science Statistics,** Vol. 10, No. 11, Statistics Canada, Catalogue No. 88-001, December 1986.

APPENDIX I

STATISTICAL TABLES

TABLE 1. Persons Engaged in R&D, by Major Field of Science and Sector

Sector	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	person-years (rounded to the nearest 10)									
Federal government	**17,190**	**16,920**	**16,470**	**16,580**	**16,250**	**16,090**	**16,590**	**17,170**	**17,220**	**17,410**
Natural sciences and engineering	15,660	15,510	15,380	15,560	15,320	15,270	15,750	16,410	16,580	16,760
Social sciences and humanities	1,530	1,410	1,090	1,020	930	820	840	760	640	650
Provincial government .	**2,730**	**3,000**	**3,170**	**3,210**	**3,450**	**3,670**	**3,660**	**4,250**	**4,140**	**3,970**
Natural sciences and engineering	2,220	2,470	2,660	2,740	2,950	3,100	3,060	3,590	3,350	3,300
Social sciences and humanities	510	530	510	470	500	570	600	660	790	670
Business enterprise (1)	**19,870**	**20,730**	**21,590**	**23,240**	**24,870**	**28,630**	**32,380**	**34,850**	**36,540**	**39,340**
Higher education	**13,200**	**13,410**	**13,520**	**13,530**	**13,530**	**13,610**	**13,490**	**13,660**	**13,760**	**14,100**
Natural sciences and engineering	7,450	7,560	7,590	7,550	7,620	7,680	7,580	7,700	7,740	8,040
Social sciences and humanities	5,750	5,850	5,930	5,980	5,910	5,930	5,910	5,960	6,020	6,060
Private non-profit	**810**	**840**	**960**	**1,120**	**1,130**	**1,190**	**1,320**	**1,440**	**1,690**	**1,850**
Total	**53,800**	**54,900**	**55,710**	**57,680**	**59,230**	**63,190**	**67,440**	**71,370**	**73,350**	**76,670**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

(1) Estimates for the Social Sciences and Humanities are unavailable.

TABLE 2. Scientists and Engineers Engaged in R&D, by Major Field of Science and Sector

Sector	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	person-years (rounded to the nearest 10)									
Natural sciences and engineering	**18,800**	**19,930**	**20,860**	**21,980**	**22,810**	**24,750**	**26,700**	**29,430**	**30,240**	**32,520**
Federal government	5,430	5,620	5,650	5,870	5,790	5,800	5,890	6,310	6,400	6,510
Provincial governments	670	740	840	840	870	820	830	1,100	930	890
Provincial research organizations	260	300	310	310	340	390	400	410	410	440
Business enterprise	8,320	9,020	9,720	10,520	11,310	13,090	14,870	16,790	17,590	19,480
Higher education	3,880	4,000	4,050	4,100	4,160	4,290	4,310	4,390	4,400	4,580
Private non-profit	240	250	290	340	340	360	400	430	510	620
Social sciences and humanities	**4,840**	**4,870**	**4,720**	**4,650**	**4,580**	**4,570**	**4,580**	**4,600**	**4,630**	**4,620**
Federal government	980	930	700	630	560	480	510	480	410	420
Provincial governments	330	340	350	300	320	370	340	360	420	380
Higher education	3,530	3,600	3,670	3,720	3,700	3,720	3,730	3,760	3,800	3,820
All sciences	**23,640**	**24,800**	**25,580**	**26,630**	**27,390**	**29,320**	**31,280**	**34,030**	**34,870**	**37,140**
Federal government	6,410	6,550	6,350	6,500	6,350	6,280	6,400	6,790	6,810	6,930
Provincial governments	1,000	1,080	1,190	1,140	1,190	1,190	1,170	1,460	1,350	1,270
Provincial research organizations	260	300	310	310	340	390	400	410	410	440
Business enterprise	8,320	9,020	9,720	10,520	11,310	13,090	14,870	16,790	17,590	19,480
Higher education	7,410	7,600	7,720	7,820	7,860	8,010	8,040	8,150	8,200	8,400
Private non-profit	240	250	290	340	340	360	400	430	510	620

Source: Statistics Canada, Science, Technology and Capital Stock Division.

TABLE 3. Technicians Engaged in R&D in the Natural Sciences and Engineering, by Sector

Sector	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	person-years (rounded to the nearest 10)									
Federal government ...	5,150	4,910	4,860	4,760	4,680	4,680	4,870	4,830	4,680	4,860
Provincial governments	560	620	630	610	700	780	740	940	820	770
Provincial research organizations	220	240	250	290	300	350	360	340	320	340
Business enterprise ..	6,590	6,910	7,230	7,570	7,910	9,450	11,000	11,550	11,480	12,630
Higher education	1,980	1,920	1,880	1,790	1,750	1,670	1,550	1,580	1,590	1,650
Private non-profit ...	370	380	430	500	510	530	590	650	790	880
Total	**14,870**	**14,980**	**15,280**	**15,520**	**15,850**	**17,460**	**19,110**	**19,890**	**19,680**	**21,130**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

TABLE 4. Other Support Staff Engaged in R&D, by Major Field of Science and Sector

Sector	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	person-years (rounded to the nearest 10)									
Natural sciences and engineering	**12,340**	**12,200**	**12,040**	**12,710**	**13,230**	**13,650**	**14,280**	**14,670**	**15,980**	**15,640**
Federal government	5,080	4,980	4,870	4,930	4,850	4,790	4,990	5,270	5,500	5,390
Provincial governments	340	380	440	500	530	520	500	560	640	640
Provincial research organizations	170	190	190	190	210	240	230	240	230	220
Business enterprise	4,960	4,800	4,640	5,150	5,650	6,080	6,510	6,510	7,470	7,230
Higher education	1,590	1,640	1,660	1,660	1,710	1,720	1,720	1,730	1,750	1,810
Private non-profit	200	210	240	280	280	300	330	360	390	350
Social sciences and humanities (1)	**2,950**	**2,920**	**2,810**	**2,820**	**2,760**	**2,750**	**2,770**	**2,780**	**2,820**	**2,760**
Federal government	550	480	390	390	370	340	330	280	230	230
Provincial governments	180	190	160	170	180	200	260	300	370	290
Higher education	2,220	2,250	2,260	2,260	2,210	2,210	2,180	2,200	2,220	2,240
All sciences	**15,290**	**15,120**	**14,850**	**15,530**	**15,990**	**16,400**	**17,050**	**17,450**	**18,800**	**18,400**
Federal government	5,630	5,460	5,260	5,320	5,220	5,130	5,320	5,550	5,730	5,620
Provincial governments	520	570	600	670	710	720	760	860	1,010	930
Provincial research organizations	170	190	190	190	210	240	230	240	230	220
Business enterprise	4,960	4,800	4,640	5,150	5,650	6,080	6,510	6,510	7,470	7,230
Higher education	3,810	3,890	3,920	3,920	3,920	3,930	3,900	3,930	3,970	4,050
Private non-profit	200	210	240	280	280	300	330	360	390	350

Source: Statistics Canada, Science, Technology and Capital Stock Division.

(1) Includes the few technicians engaged in R&D in the social sciences and humanities.

TABLE 5. Federal Employees Engaged in R&D in the Natural Sciences and Engineering, by Department

Department	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	person-years									
Agriculture Canada	3,994	3,901	3,868	3,864	3,811	3,788	3,887	3,916	4,804(1)	4,727(1)
Atomic Energy of Canada Ltd	2,333	2,223	2,177	2,250	2,206	2,260	2,340	2,451	2,500	2,484
Energy, Mines and Resources	1,250	1,244	1,241	1,416	1,374	1,376	1,381	1,468	1,530	1,655
Environment Canada	2,826	2,907	2,916	1,591	1,599	1,612	1,616	1,632	849(1)	867(1)
Fisheries and Oceans	-	-	-	1,278	1,207	1,228	1,384	1,486	1,502	1,533
National Defence	1,880	1,800	1,814	1,775	1,760	1,730	1,795	1,776	1,805	1,782
National Research Council	2,384	2,379	2,372	2,363	2,437	2,404	2,435	2,715	2,762	2,841
Other	993	1,048	994	1,021	918	880	914	968	836	870
Total	**15,660**	**15,502**	**15,382**	**15,558**	**15,312**	**15,278**	**15,752**	**16,412**	**16,588**	**16,759**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

(1) In 1983, responsibility for the Canadian Forestry Service Program was transfered from Environment Canada to Agriculture Canada.

TABLE 6. Persons Engaged in R&D in the Business Enterprise Sector, by Industry and Occupation, 1984

Industry	Professionals	Technicians	Other	Total
	person-years (rounded to the nearest 5)			
Mining and oil wells	**585**	**430**	**205**	**1,220**
Mining	335	325	110	770
Crude petroleum and natural gas	250	105	95	450
Manufacturing	**14,050**	**9,220**	**5,870**	**29,140**
Food, beverages and tobacco	610	450	225	1,285
Rubber and plastic products	145	120	60	325
Textiles	80	45	80	205
Wood	145	70	60	275
Pulp and paper	395	385	175	955
Primary metals (ferrous)	170	90	60	320
Primary metals (non-ferrous)	445	575	235	1,255
Metal fabricating	190	175	70	435
Machinery	395	455	380	1,230
Aircraft and parts	1,475	1,130	930	3,535
Other transportation equipment	615	450	310	1,375
Telecommunication equipment	3,150	1,300	1,685	6,135
Electronic parts and components	500	270	140	915
Other electronic equipment	1,210	775	265	2,245
Business machines	1,250	595	285	2,125
Other electrical products	575	525	125	1,225
Non-metallic mineral products	85	100	25	215
Refined petroleum and coal products	625	525	210	1,365
Drugs and medicines	360	135	180	675
Other chemical products	1,170	705	230	2,105
Scientific and professional equipment	290	215	60	565
Other manufacturing industries	175	135	70	375
Services	**4,845**	**2,980**	**1,155**	**8,980**
Transportation and other utilities	1,295	520	215	2,030
Electrical power	645	555	255	1,455
Computer services	825	340	230	1,395
Engineering and scientific services	1,530	1,145	355	3,025
Other non-manufacturing industries	550	425	100	1,075
Total, all industries	**19,480**	**12,630**	**7,230**	**39,340**

Source: Statistics Canada, Science, Technology and Capital Stock Division.

TABLE 7. Professional Personnel Engaged in R&D, by Industry Group and Degree Level

Industry	Bachelors	Masters	Doctorate	Total
	person-years (rounded to the nearest 5)			
Mining and oil wells				
1975	185	40	55	285
1977	170	45	50	265
1979	210	65	80	350
1981	385	80	125	595
1982	305	70	120	495
1983	295	80	135	510
1984	355	95	130	585
Manufacturing				
1975	4,585	1,320	1,185	7,095
1977	5,000	1,525	1,345	7,870
1979	6,150	1,635	1,440	9,230
1981	7,685	1,990	1,705	11,380
1982	8,580	2,365	1,765	12,705
1983	8,900	2,405	1,695	13,000
1984	9,610	2,720	1,720	14,050
Services				
1975	545	180	210	935
1977	970	355	260	1,585
1979	1,085	380	265	1,730
1981	1,850	580	465	2,895
1982	2,315	720	555	3,590
1983	2,820	700	555	4,075
1984	3,365	835	645	4,845
Total				
1975	5,320	1,540	1,455	8,315
1977	6,140	1,925	1,655	9,720
1979	7,445	2,075	1,785	11,310
1981	9,925	2,650	2,295	14,865
1982	11,200	3,155	2,440	16,795
1983	12,020	3,180	2,390	17,590
1984	13,335	3,650	2,495	19,480

Source: Statistics Canada, Science, Technology and Capital Stock Division.

TABLE 8. Professional Personnel Engaged in R&D, by Industry and Degree Level, 1984

Industry	Bachelors	Masters	Doctorate	Total
	person-years (rounded to the nearest 5)			
Mining and oil wells	**355**	**95**	**130**	**585**
Mining	225	45	65	335
Crude petroleum and natural gas	130	55	65	250
Manufacturing	**9,610**	**2,720**	**1,720**	**14,050**
Food, beverages and tobacco	425	85	100	610
Rubber and plastic products	85	20	45	145
Textiles	55	10	10	80
Wood	75	35	35	145
Pulp and paper	200	60	135	395
Primary metals (ferrous)	125	25	15	170
Primary metals (non-ferrous)	215	110	125	445
Metal fabricating	145	30	10	190
Machinery	370	20	5	395
Aircraft and parts	1,125	270	80	1,475
Other transportation equipment	535	60	20	615
Telecommunication equipment	2,015	865	270	3,150
Electronic parts and components	415	70	15	500
Other electronic equipment	820	285	100	1,210
Business machines	910	250	90	1,250
Other electrical products	475	75	25	575
Non-metallic mineral products	55	20	10	85
Refined petroleum and coal products	290	125	215	625
Drugs and medicines	145	60	155	360
Other chemical products	780	170	220	1,170
Scientific and professional equipment	210	45	35	290
Other manufacturing industries	140	25	10	175
Services	**3,365**	**835**	**645**	**4,845**
Transportation and other utilities	975	235	85	1,295
Electrical power	240	185	225	645
Computer services	735	60	30	825
Engineering and scientific services	1,000	280	250	1,530
Other non-manufacturing industries	415	75	60	550
Total, all industries	**13,335**	**3,650**	**2,495**	**19,480**

Source: Statistics Canada, Science, Technology and Capital Stock Division

TABLE 9. Scientists and Engineers Engaged in R&D in Selected OECD Countries(1)

Country	1971	1973	1975	1977	1979	1981	1983
Scientists and engineers	**full-time equivalent**						
United States	527,100	518,400	532,700	570,300	614,800	683,700	722,900
Japan (2)	247,309	292,097	316,860	331,467	363,534	392,625	435,340
Germany	90,206	101,019	103,736	110,972	121,978	127,364	133,114
France	60,100	62,700	65,300	67,981	72,889	85,500	92,682
Canada	**-**	**21,734**	**23,640**	**25,580**	**27,390**	**31,280**	**34,880**
Netherlands	14,192	14,247	15,460	17,368	18,450	19,436	21,550
Sweden	-	12,362	14,759	-	11,760	15,035	17,044
Switzerland	8,541	9,854	10,568	11,835	10,720	-	-
Total labour force	**thousands**						
United States	87,198	91,756	95,955	101,142	106,559	110,315	113,226
Japan	51,860	53,260	53,230	54,520	55,960	57,070	58,890
Germany	26,910	26,985	26,397	26,074	26,923	27,416	27,589
France	21,638	22,083	22,310	22,697	23,266	23,532	23,690
Canada	**8,727**	**8,358**	**10,059**	**10,578**	**11,305**	**11,978**	**12,258**
Netherlands	4,793	4,802	4,862	4,877	5,207	5,593	5,836
Sweden	3,961	3,977	4,129	4,174	4,268	4,332	4,375
Switzerland	3,167	3,203	3,027	2,935	3,109	3,217	3,178
Scientists and engineers per 10,000 persons in the labour force	**ratio**						
United States	60.4	56.5	55.5	56.4	57.7	62.0	63.8
Japan	47.7	54.8	59.5	60.8	65.0	68.8	73.9
Germany	33.5	37.4	39.2	42.6	45.3	46.5	48.2
France	27.8	28.4	29.3	30.0	31.3	33.5	39.1
Canada	**-**	**26.0**	**23.5**	**24.2**	**24.2**	**26.1**	**28.5**
Netherlands	29.6	29.7	31.8	35.6	35.4	34.8	36.9
Sweden	-	31.1	35.7	-	27.6	34.7	39.0
Switzerland	27.0	30.8	34.9	40.3	36.1	-	-

Source: "Science and Technology Indicators. Basic Statistics Series, Volume C, Total R&D Personnel", OECD DSTI/SPR/82.59, Paris, 1982.
"Recent Results 1979-1986", OECD, Paris, September 1986.
Statistical Yearbook, UNESCO, Paris, 1981.
"Labour Force Statistics, 1962-1982", OECD, Paris, 1983, p. 19.

(1) Both the natural sciences and engineering and social sciences and humanities combined.
(2) Overestimated (not in full-time equivalent).

APPENDIX II

TECHNICAL NOTES

R&D personnel statistics are not always compatible because "a wide variety of persons are needed in the national R&D effort: from the Nobel prize-winner to the winner's secretary, from the designer of space experiments to the breeder of laboratory animals".(1) Consequently, it is essential to separate R&D personnel into categories. Two classification systems are currently in use by OECD member countries: classification by occupation and classification by level of formal qualification.

The former, the International Standard Classification of Occupation (ISCO), distinguishes three occupational levels: researchers, technicians and equivalent staff, and other supporting staff. The corresponding formal qualification categories are: university graduates, holders of other postsecondary diplomas and high-school graduates. They correspond respectively to the International Standard Classification of Education (ISCED) level categories 6 and 7, 5 and 3, an established classification system of the United Nations. The suggested relation between the classification system used by OECD member countries and the ISCO are presented in the following table (next page).

Canada uses primarily the occupational classification; the three levels are defined below.

Scientists and engineers are engaged in the conception or creation of new knowledge, products, processes, methods and systems. This level also includes managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work. They are usually equal in rank to the researchers and are often former or part-time researchers themselves. Post-graduate students, in particular those performing significant amounts of R&D, are included in this category.

Technicians participate in R&D projects by performing tasks normally under the supervision of scientists and engineers or researchers in the social sciences and humanities. These tasks might include, for example, preparing computer programs, carrying out tests and experiments or statistical surveys and interviews.

Other support staff include skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects. Those providing an indirect service, such as canteen and cleaning staff, should be excluded.

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(1) **The Measurement of Scientific and Technical Activities, "Frascati Manual"**, 1981, p. 19.

Personnel Engaged in R&D by Occupational Classification (Suggested Relation Between OECD and ISCO (1) Classes)

OECD class	ISCO classes	ISCO numbers
Researchers	Chemists, physicists, physical scientists, n.e.c.	011, 012 and 013
	Biologists, medical scientists and related scientists, bacteriologists and related scientists, agronomists and related scientists	051, 052 and 053
	Statisticians, mathematicians and actuaries, systems analysts	081, 082 and 083
	Economists	090
	Lawyers, jurists, n.e.c.	121 and 129
	Sociologists, psychologists, anthropologists, geographers, historians and political scientists	192
	Librarians, archivists and curators	191
	Civil, electrical, mechanical, chemical, metallurgical, mining and industrial engineers, and engineers n.e.c.	022-029 inclusive
	University and higher education teachers	131
	Administrators and managerial workers (part)	Major group 2
Technicians and equivalent staff	Physical and life science technicians	014 and 054
	Surveyors, draughtsmen, civil, electrical, mechanical, chemical, metallurgical, mining and other engineering technicians	031-039 inclusive
	Statistical and mathematical technicians, including computer programmers	084
	(Survey interviewers)	(none)

Personnel Engaged in R&D by Occupational Classification (Suggested Relation Between OECD and ISCO (1) Classes) - Concluded

OECD class	ISCO classes	ISCO numbers
Other supporting staff	Agricultural, service and production and related workers	Major groups 6, 7, 8 and 9
	Clerical workers and related workers	Major group 3
	Administrators and managerial workers, n.e.c.	Major group 2

Source: **Frascati Manual**, OECD, Paris, 1981, p. 68.

(1) International Standard Classification of Occupation.

OTHER DEFINITIONS AND CLASSIFICATIONS:

Since most workers do not all spend the same amount of time on R&D, it is necessary to express the number of persons performing R&D in terms of **full-time equivalents (FTE)** or **person-years.** If only those persons employed in pure R&D are counted, the number of R&D personnel will be understated, just as counting every person who spends part of his/her time on R&D will result in an overstatement. On a full-time equivalent basis then, a person devoting a third of his/her time to R&D will be counted as 0.3 of a person-year. Formally;

Persons engaged in R&D: Calculated in full-time equivalent (FTE). R&D may be performed by persons who devote all their time to this activity or by persons who spend only part of their time on it and the rest on duties such as testing, quality control and production management. To determine the total effort devoted to R&D in person-years, the number of persons engaged only part-time in R&D must be converted to full-time equivalents.

Scientific activities: Are concerned with the generation, dissemination and initial application of new scientific and technical knowledge. The central activity is R&D (scientific research and experimental development), but there are other activities closely connected with R&D. In the natural sciences field, the federal government may be involved in scientific data collection, information services, testing and standardization, feasibility studies, education support and museum services. In the social sciences, it may engage in general purpose data collection, information services, economic and feasibility studies, operations and policy studies, education support and museum services. For further information see, **A Framework for Measuring Research and Development Expenditures in Canada,** Statistics Canada, Catalogue No. 88-506E.

R&D: Scientific research and experimental development, comprising creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications.

Natural sciences and engineering: Disciplines concerned with understanding, exploring, developing or using the natural world. They comprise engineering, mathematics, the life sciences and the physical sciences.

Social sciences and humanities: Disciplines concerned with human actions and conditions and the social, economic and institutional mechanisms affecting human beings. Included are anthropology, business administration and commerce, communications, criminology, demography, economics, geography, history, languages, literature and linguistics, law, library science, philosophy, political science, psychology, religious studies, social work, sociology and urban and regional studies.

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88-509 **Price Indexes for Canadian Industrial Research and Development Expenditures**
Price: Canada, $20.00, other countries, $21.00.

The above catalogued publications can be purchased from Publications Sales, Statistics Canada (Ottawa).

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Working papers of the Science and Technology Statistics Section

Estimates of Canadian Research and Development Expenditures, by Region, 1979-1985

Canadian Patent Trends, 1984

Indicators of Canadian Research Output, 1982

The Measurement of Industrial Innovation

Estimation of R&D Expenditures in the Higher Education Sector, 1985-86

Federal Personnel Engaged in Scientific Activities, 1977-78 to 1986-87

Federal Government Expenditures on Activities in the Natural Sciences, 1963-64 to 1986-87

Federal Government Expenditures on Activities in the Social Sciences and Humanities, 1970-71 to 1986-87

Scientific and Technological Activities of Provincial Governments, 1978-1979 to 1986-87

Canadian Indicators of the International Transfer of Technology

Trade in "High Technology Products", 1978-1986

Questionnaires Used for the Collection of Science and Technology Statistics in 1987

Federal Science Expenditures and Personnel, 1977-88

Estimation of Invisible R&D: An Exploratory Model

The above working papers are available free of charge from the Science and Technology Statistics Section.

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00650204 - Sources of Funds for Intramural R&D, by Industry, 1985

00650205 - Number of Persons Engaged in R&D, by Industry and by Occupational Category, 1985

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